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Investigation of industrial compositions SONKOR as corrosion inhibitors of mild steel in neutral media containing hydrogen sulfide

Electrochemical and corrosion behavior of mild steel in neutral media containing hydrogen sulfide has been investigated by weight-loss and electrochemical methods and protective effect of industrial compositions SONKOR has been determined. It has been shown that in 3 % NaCl compositions SONKOR have weak protective effect but it increases greatly in presence of hydrogen sulfide in the solution. At concentration of H_2S = 0,6 gram per liter maximal protective effect has SONKOR 9801 (85.57 %) and SONKOR 9920A (81.97 %). Inhibitors SONKOR 9021C (70.82 %), 9510A (73.11 %) и 9701 (67.87 %) show less protective effect.

Key words: Electrochemistry; corrosion behavior; of industrial compositions SONKOR; hydrogen sulfide

Introduction

The corrosion of metals causes a great harm to many industries, primarily to the enterprises of oil and gas production and petroleum refining. This is due to the aggressive properties of corrosive environments in oil, which are caused by the presence of mineralized water, hydrogen sulfide and sulphate-reducing bacteria, and carbon dioxide. Some of the most economical and efficient methods of metal protection methods are associated with the use of corrosion inhibitors [1]. Inhibitors in these industries are applied at all stages of processing, transportation of oil, gas and petrochemicals. Protection of metals from corrosion inhibitors based on the property of some individual chemical compounds or their mixtures when introduced in low concentrations in the corrosive environment to reduce the rate of corrosion of the process or completely suppress it.

The aim of this work was to study the effectiveness of a range of industrial compositions series SONKOR as inhibitors of the corrosion of S31600 steel in neutral hydrogen sulfide-containing environments.

Experimental technique

The studies of inhibitors was carried out by the gravimetric and electrochemical methods. The gravimetric method is to determine the corrosion rate by the mass loss of the samples. The electrochemical method consists in removing the polarization curves using a potentiostat-galvanostat with built in frequency analyzer Solartron 128 °C (Solartron Analytical), the calculation coefficients, which determine the mechanism of action of corrosion inhibitors of tested metal, as well as in determining the corrosion rate of metal by extrapolation plots of the polarization curve at the corrosion potential of E_{cor}. The chemical compounds were studied in the work as inhibitors of the industrial composition of domestic production series SONKOR (company "Neftehim", Ufa). The gravimetric method was studied the protective action of inhibitors at concentrations: 0.025; 0.050; 0.100; 0.200 g/l. In the electrochemical studies was chosen as the optimal concentration of the inhibitor is 0.100 g/L.

The experiment was carried out in 3 % NaCl solution, and, when introduced into a solution of various concentrations of H_2S (0.1; 0.2; 0.4; 0.6 g/l). The working solutions were prepared with distilled water. A hydrogen sulfide is received directly in the working solution by introducing appropriate quantities of Na_2S and HCl.

Results and discussions

The results of gravimetric determination of corrosion rate of mild steel S31600 in 3 % NaCl and the impact of hydrogen sulfide and the studied inhibitors SONKOR are shown in table 1. It is seen that in the absence of hydrogen sulfide inhibitors have a weak protective effect (Z), and SONKOR 9701 and does not have any effect. The introduction of hydrogen sulfide into a solution of 3 % NaCl significantly increases the corrosion rate of steel (0.149 g/(m^2·h) to 0.578 g/(m^2·h)) at H_2S concentration of 0.4 g/l and up to 0.747 g/(m^2·h) at H_2S concentration of 0.6 g/L. The protective effect of inhibitors also significantly increased in the presence of hydrogen sulfide and the increase of its concentration in solution. Among the investigated compositions proved to be most effective composition SONKOR 9801 and SONKOR A, a protective effect which increased to 85.57 and 81.97 %, respectively. The average protective effect (Z < 75 %) were showed by the inhibitors SONKOR 9021C, 9510A and 9701.

The protective effect of inhibitors of SONKOR markedly increased in a neutral environment in the presence of hydrogen sulfide, which in itself is a powerful stimulant corrosion. This is probably due to the synergistic action of the inhibitors and the hydrogen sulfide. It is known that organic amendments enter into a chemical reaction with hydrogen sulfide, forming on the steel surface protective film of insoluble or sparingly soluble compounds. There is a joint effect of the inhibitor and the shielding layer of corrosion products on the development of the corrosion process.

The results of the study of protective action of the inhibitors SONKOR method of polarization curves presented in tables 2–4. The polarization curves is widely used in corrosion the for the study of corrosion inhibitors because it allows you to

calculate the corrosion rate cor in units of current density, to determine a slopes of the polarization curves b_k and b_a, the corrosion potential of E_{cor}, and also to determine what type of inhibitor is part of the test substance: which of the partial electrode reactions (release of hydrogen, the ionization of oxygen or ionization of metal) mainly slows down the inhibitor.

The results showed that inhibitors of SONKOR 9510A and 9021C increase the polarizability of the anode process, therefore they can be classified as anodic type inhibitors. The CONCOR 9701, 9801 and 9920A inhibitors are mixed type of one.

Introduction to the NaCl solution of hydrogen sulfide leads to a parallel shift of the polarization curves at higher currents, which ultimately accelerates the overall corrosion of the S31600 steel. The electrochemical studies were performed in solutions containing 0.6 g/l of H_2S, because the concentration of hydrogen sulfide is most strongly accelerated corrosion of steel. In inhibited H_2S-containing solutions catigny and anodic currents decreased markedly, which confirmed the results of gravimetric test the higher efficiency of the inhibitors SONKOR in the presence of hydrogen sulfide. The discrepancy between the values of the protective action of inhibitors in gravimetric (Z_{gr}) and electrochemical methods ($Z_{e/x}$) is due to the fact that in the weight

Table 1

The corrosion of steel and the protective action of inhibitors SONKOR (0.1 g/l) in 3 % NaCl + H_2S

The inhibitor	3 % NaCl		3 % NaCl + H_2S					
			0.2 g/L H_2S		0.4 g/L H_2S		0.6 g/L H_2S	
	K, g/m²·h	Z, %	K, g/m²·h	Z, %	K, g/m²·h	Z, %	K, g/m²·h	Z, %
Not	0.150	–	0.368	–	0.578	–	0.748	–
SONKOR 9021C	0.123	18.03	0.186	49.33	0.201	65.25	0.218	70.82
SONKOR 9510A	0.125	16.39	0.189	48.67	0.213	63.14	0.201	73.11
SONKOR 9701	0.152	0	0.150	59.33	0.189	67.37	0.240	67.87
SONKOR 9801	0.135	9.83	0.120	67.33	0.125	78.39	0.108	85.67
SONKOR 9920A	0.125	16.39	0.142	61.33	0.152	73.73	0.135	81.97

Table 2

The corrosion-electrochemical properties of Steel in 3 % NaCl solution in the presence of 0.1 g/L inhibitors

The inhibitor (0, 1 г/л)	$-E_{cor}$, V	b_a, mV	$b_к$, mV	i_{cor}, A/m²	Zrp, %	Ze/x, %
–	0.545	138	245	0.105	–	–
SONKOR 9021C	0.408	64	263	0.101	18.03	3.45
SONKOR 9510A	0.413	65	162	0.088	16.39	15.94
SONKOR 9701	0.418	76	259	0.072	0	31.58
SONKOR 9801	0.432	79	240	0.069	9.83	34.26
SONKOR 9920A	0.458	76	151	0.030	16.39	71.56

Table 3

The corrosion-electrochemical properties of steel in 3 % NaCl solution + H_2S (c = 0.1; 0.2; 0.4; 0.6 g/L)

Concetration of H_2S, g/L	$-E_{cor}$, V	b_a, mV	$b_к$, mV	i_{cor}, A/m²
0	0.545	138	245	0.105
0.1	0.428	89	870	0.304
0.2	0.403	77	384	0.397
0.4	0.397	89	419	1.057
0.6	0.397	111	440	1.371

Table 4

The corrosion-electrochemical properties of steel in 3 % NaCl solution+ H_2S (0.6 g/L) in the presence of 0.1 g/L inhibitors

The inhibitor (0, 1 г/л)	$-E_{cor}$, V	b_a, mV	$b_к$, mV	i_{cor}, A/m²	$Z_{гр}$, %	$Z_{э/х}$, %
–	0.397	111	440	1.371	–	–
SONKOR 9021C	0.399	92	369	0.409	70.82	70.16
SONKOR 9510A	0.407	94	465	0.370	73.11	73.00
SONKOR 9701	0.410	92	506	0.334	67.87	75.62
SONKOR 9801	0.412	98	764	0.408	85.57	70.88
SONKOR 9920A	0.383	87	546	0.342	81.97	75.10

measurements to determine the average corrosion rate over 24 h and during the electrochemical measurements of the corrosion rate at the moment.

The system *metal– water–hydrogen sulfide* is a very complex and even equilibrium can be many reactions to form a variety of compounds. When considering the mechanism of hydrogen sulfide corrosion, it should be borne in mind that, depending on pH in solutions of electrolytes, the hydrogen sulfide may be present in different forms at pH < 6 the main part is in the form of molecular dissolved gas, at pH > 6 in the form of SH^-, in alkaline electrolytes – S^{2-}. A significant effect of pH on the rate of hydrogen sulfide corrosion is determined by kinetic reasons associated with resistance resulting from corrosion of the films. The presence of sulfide and hydrosulfide ions in corrosive environment contributes to a dramatic stimulation of both partial electrochemical reactions at the steel[2] .

The presence in a corrosive environment H_2S and O_2 leads to further destruction of the metal, possibly because of the reaction in which the intermediate product H_2S_2 is a depolarizer which is equal to the oxygen[3] .

Conclusion

In the environment of hydrogen sulfide inhibitors series SONKOR dramatically increase its effectiveness in neutral solution. They can be attributed to the class of mixed-type inhibitors, because they inhibit both the partial electrochemical process, but more particularly inhibitors inhibit the cathodic process that occurs with a mixed oxygen-hydrogen depolarization.

1. Kim Ya. R., Tsygankova L. E., Kichigin V. I. *Korrozija: materially, zaschita*. 2005;8: 30.
2. I. L. Rosenfeld, *Ingibitory korrozii*, Khimiya, Moscow, 1978. 300 pp. (In Russian).
3. Yashina G. M., Bobov S. S., Smolenskaya E. A. *Korrozija i zaschita v neftegaz. promyshl*. 1980;8: 24.